

Interface Structure as Admissibility and Composition Constraints - A Level-Dependent Framework for Relational Physical Theories

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Abstract

Relational approaches to physics assign physical meaning to quantities through interactions rather than through intrinsic properties of isolated systems. However, once relational information is established locally and later propagated or compared across multiple contexts, additional admissibility and compositional constraints become necessary to determine how such information may be consistently translated, filtered, or combined. Prior work established that local relational assignments together with accessibility structure are, in general, insufficient to determine unique cross-context composition outcomes.

The present work develops a level-dependent interpretation of admissibility and compositional constraints within relational physical frameworks. Rather than introducing new dynamical entities or physical media, the framework treats such constraints operationally as governing which relational descriptions are physically admissible and

how relational information may be consistently composed across contexts.

A central result of the paper is that these constraints admit complementary operational interpretations across levels of description. At the level of relational fact comparison, they act on already-established relational information through compositional maps governing propagation and comparison across contexts. At a more abstract level, the same constraints may instead be interpreted as restricting the admissible organization of relational configurations themselves. These interpretations are shown to be complementary rather than circular, reflecting different descriptive roles within the same structural framework.

The proposed interpretation remains compatible with existing approaches including relational quantum mechanics, decoherence-based descriptions, gauge-theoretic transition structure, and information-theoretic formulations, while leaving their underlying dynamics unchanged. Representative physical constraint classes discussed within the framework include causality, consistency, stability, and information-theoretic limitations, although no unique realization of such constraints is specified.

The framework is intentionally structural, interpretive, and ontology-neutral in scope. Its principal contribution is to clarify the role of admissibility and compositional constraints in maintaining compositionally consistent relational descriptions across multiple interaction contexts.

1 Introduction

Relational approaches to physics assign physical meaning to quantities through interactions rather than through intrinsic properties of isolated systems. This perspective appears in quantum foundations, gauge theory, and network-based descriptions of physical information [1, 2, 3]. However, relational descriptions alone do not, in general, determine how locally established facts may be consistently compared, propagated, or composed across extended chains of interaction.

Prior work established a minimal necessity result: local relational assignments together with accessibility structure are generically insufficient to determine unique cross-context composition outcomes [4]. Whenever relational descriptions are extended beyond isolated interactions and later

compared across multiple contexts, additional constraints are required to regulate admissibility, consistency, and composition.

The present paper addresses the following complementary question:

How should this additional compositional structure be interpreted once its necessity is established?

We propose that the required structure may be understood operationally as a system of admissibility and composition constraints governing relational descriptions. In this interpretation, interfaces do not represent physical boundaries or additional dynamical entities. Rather, they specify which relations are physically realizable, how relational information may be transferred between contexts, and under what conditions relational descriptions remain mutually consistent.

A central claim of this work is that the role of such constraints is level-dependent. At the level of relational fact comparison, they appear as compositional rules acting on already established relational information. At a more abstract level, the same constraints may instead be interpreted as restricting the admissible space of relational configurations. These descriptions are complementary rather than circular, reflecting different levels of structural organization within relational frameworks.

The framework developed here is intentionally ontology-neutral. It does not assert whether relational descriptions or interface constraints are fundamentally prior in an absolute sense. Instead, it isolates a structural interdependence: relational descriptions require admissibility and composition constraints for consistent cross-context comparison, while such constraints are defined operationally through their action on relational structures.

The goal of this paper is not to introduce new microphysical dynamics or replace existing physical theories. Rather, it develops a structural interpretation of admissibility and composition constraints that is compatible with existing relational, information-theoretic, and geometric frameworks, while clarifying the minimal conditions required for coherent relational composition across contexts.

2 Background: Interface Necessity

Prior work established a minimal structural result concerning relational descriptions across multiple interaction contexts [4]. Specifically, local relational

fact assignments together with accessibility structure were shown to be, in general, insufficient to determine unique cross-context composition outcomes.

Whenever a framework permits both:

1. locally generated relational facts, and
2. subsequent comparison across multiple contexts,

additional constraints are generically required to regulate how relational information may be consistently propagated or composed.

This additional structure was termed *interface structure* and was introduced operationally through maps between relational contexts. The necessity result was intentionally limited in scope: it did not specify the detailed form of such structure, its physical realization, or its ontological status.

The present work adopts this necessity result as a starting point and focuses instead on interpretation. The central question addressed here is not whether additional compositional constraints are required, but how such constraints may be understood within relational physical frameworks once their necessity is established.

3 Interface Structure as Admissibility Constraint

We interpret interface structure operationally as a system of admissibility constraints acting on relational descriptions. In this formulation, interfaces are not introduced as additional dynamical entities or independent physical substances. Rather, they specify which relational configurations and transformations remain physically admissible within a given framework.

Let $\mathcal{R}$ denote the space of possible relational configurations between systems. An interface structure $\mathcal{I}$ defines an admissible subset

$$\mathcal{R}_{\text{adm}} \subseteq \mathcal{R}, \tag{1}$$

consisting of configurations compatible with the relevant physical constraints.

The interface structure therefore governs:

- which interactions may produce physically meaningful relational facts;
- which transformations between relational contexts are permitted;

- and which configurations are excluded by consistency, causality, stability, or accessibility constraints.

Within this interpretation, interface structure acts as a constraint layer on relational configuration space rather than as a separate dynamical sector.

This perspective shifts the emphasis from composition alone to admissibility-constrained composition. The role of interface structure is therefore not limited to regulating how relational information is combined after the fact, but also includes constraining which relational configurations may consistently participate in physical composition processes at all.

4 Interface Structure as Composition Constraint

In addition to restricting admissible relational configurations, interface structure may also be interpreted operationally as regulating how relational information is composed across contexts. This compositional role reflects the minimal requirement identified in prior work: once relational facts are generated locally and later compared across multiple interaction contexts, additional constraints are required to determine how such information may be propagated, combined, transformed, or filtered.

Let F_α and F_β denote relational fact spaces associated with distinct interaction contexts α and β . Interface maps are then introduced in the form

$$I_{\alpha \rightarrow \beta} : F_\alpha \rightarrow F_\beta, \quad (2)$$

where the map specifies how relational information established in one context may contribute to or constrain relational descriptions in another.

Operationally, such maps may perform several compositional functions, including:

- *Translation*: mapping relational descriptions between contexts with different representations or bases;
- *Filtering*: restricting which components of a relational fact are retained or propagated;
- *Coarse-graining*: reducing detailed relational information to lower-resolution effective descriptions;

- *Compatibility enforcement*: ensuring that composed relational facts satisfy consistency conditions;
- *Equivalence identification*: specifying when distinct relational descriptions correspond to the same effective relational content.

Within the present interpretation, these operations do not generate relational facts themselves. Rather, they regulate how already-established relational information may be transformed, filtered, coarse-grained, and compared across contexts under admissibility constraints. Their role is therefore compositional rather than dynamical: they act on existing relational information, determining how such information may participate in subsequent relational comparisons and interactions.

4.1 Composition Paths and Path Dependence

Consider a sequence of interaction contexts

$$\alpha \rightarrow \beta \rightarrow \gamma. \quad (3)$$

Relational information may be propagated along this chain through composition of interface maps:

$$F_\alpha \xrightarrow{I_{\alpha \rightarrow \beta}} F_\beta \xrightarrow{I_{\beta \rightarrow \gamma}} F_\gamma. \quad (4)$$

The resulting transformation is represented by the composed map

$$I_{\beta \rightarrow \gamma} \circ I_{\alpha \rightarrow \beta}. \quad (5)$$

In general, such compositions need not be path-independent. If multiple admissible routes exist between relational contexts, one may have

$$I_{\beta \rightarrow \gamma} \circ I_{\alpha \rightarrow \beta} \neq I_{\alpha \rightarrow \gamma}. \quad (6)$$

This path dependence reflects the possibility that relational information may be filtered, transformed, or coarse-grained differently depending on the sequence of interactions through which it propagates. Consequently, global relational descriptions may depend not only on local interaction structure, but also on the compositional history relating distinct contexts.

The present framework does not assume that all relational systems necessarily exhibit nontrivial path dependence. Rather, the possibility of such dependence arises naturally whenever relational information is propagated through multiple admissible compositional channels with distinct transformation properties.

4.2 Composition Constraints

The admissibility of composed relational descriptions is not determined by local relational facts alone. Additional compositional constraints are therefore required to regulate how relational information may be consistently propagated across multiple contexts.

Representative compositional constraints include:

- *Consistency*: composed relational descriptions must remain mutually compatible within the receiving context;
- *Causality*: compositional processes must respect accessibility and ordering relations between contexts;
- *Stability*: only relational structures satisfying the relevant stability conditions may persist through extended compositional chains;
- *Equivalence preservation*: relational descriptions identified as equivalent at one level must remain compatible under admissible transformations.

These constraints restrict the space of admissible compositions, limiting how relational information may be transformed, propagated, or combined across distinct interaction contexts. Their role is not to generate relational content, but to regulate the conditions under which compositional processes remain physically and structurally coherent.

4.3 Interface Structure as Compositional Layer

Within the present interpretation, interface structure may be understood as an additional compositional framework acting on relational descriptions. Given:

- a set of systems capable of interaction;
- locally generated relational facts;
- and accessibility relations specifying possible interactions,

the framework introduces additional compositional constraints governing how relational information may be propagated, transformed, filtered, or compared across extended interaction networks.

This interpretation emphasizes that such compositional constraints act on an already-defined relational and accessibility structure rather than introducing new dynamical content or independent physical entities.

At the operational level considered here, interface maps regulate how relational information may participate in admissible compositional processes across multiple contexts.

4.4 Transition to Level-Dependent Interpretation

The operational interpretation developed above does not exhaust the possible descriptive roles of admissibility and compositional constraints. The following section examines how the same compositional structure may admit different interpretations across descriptive levels.

5 Level-Dependent Interpretation of Interface Structure

We now examine how the compositional framework developed above may admit different interpretations across distinct descriptive levels.

5.1 Distinct Levels of Description

We distinguish schematically between two descriptive organizations of the same compositional framework:

1. *Relational description.* At this level, the framework is organized around relational facts established through interactions between systems. The compositional constraints appear operationally as maps acting on relational fact spaces, governing admissibility, translation, filtering, and composition across contexts.
2. *Constraint-based description.* At a more abstract descriptive level, one may instead focus on the admissible organization of relational configurations themselves. In this interpretation, the compositional constraints act by restricting which relational configurations may be physically realized and how they may be consistently combined.

These descriptions do not represent distinct physical theories or independent ontological layers. Rather, they correspond to different ways of organizing and interpreting the same relational-compositional structure.

5.2 Operational Role at the Relational Level

At the level of relational fact assignment, compositional constraints act operationally on relational information that has already been established through local interactions. Interface maps then regulate how such relational information may be compared, propagated, filtered, or composed across distinct contexts.

Within this description:

- relational facts are treated as already-defined inputs;
- compositional constraints act on these relational descriptions;
- and composition rules are applied after local fact formation.

Accordingly, the compositional framework appears at this descriptive level as an additional organizational structure introduced to regulate the consistency and admissibility of relational descriptions across contexts. Its role is therefore to constrain how relational information may be used and composed rather than to generate relational content itself.

5.3 Constraint-Level Interpretation

At a more abstract descriptive level, the same compositional constraints may instead be interpreted as restricting the admissible organization of relational configurations. In this interpretation, the constraints do not act on already-established relational descriptions alone, but also characterize which relational configurations remain physically admissible within the framework.

Within this description:

- the space of relational configurations is restricted by admissibility conditions;
- compositional constraints regulate which relational configurations remain physically consistent;

- and only admissible relational configurations participate in subsequent relational composition processes.

The distinction is therefore organizational rather than ontological, reflecting different descriptive interpretations of the same compositional structure.

5.4 Complementary Descriptive Roles

The two interpretations developed above are complementary rather than competing because they operate at different descriptive levels within the same compositional framework. At the relational level, the framework regulates the admissible propagation and comparison of already-established relational information. At a more abstract level, the same structure restricts the admissible organization of relational configurations themselves.

5.5 Comparison with Binary Source–Geometry Descriptions

Many physical frameworks organize variables schematically into two broad descriptive classes:

- source-like variables, associated primarily with state, excitation, or information content;
- geometry-like variables, associated primarily with accessibility, interaction structure, or relational organization.

The compositional framework developed here introduces an additional organizational role associated with admissibility and composition constraints. The level-dependent interpretation developed above suggests that such constraints may not fit naturally within a purely binary source–geometry classification.

At the relational level, these compositional constraints appear operationally as additional structures regulating how relational information may be propagated and compared across contexts. At a more abstract descriptive level, the same constraints may instead be interpreted as restricting the admissible organization of source-like and geometry-like descriptions themselves.

This perspective suggests that the distinction between source-like, geometry-like, and compositional roles may depend on descriptive context rather than representing a fixed or universally absolute classification.

5.6 Minimal Claim

The present framework does not require treating compositional constraints as fundamentally primary or ontologically distinct from relational structure. Rather, it advances a narrower and more operational claim:

Compositional constraints may admit different descriptive interpretations across levels of analysis, acting operationally on already-established relational information at one level while restricting the admissible organization of relational configurations at another.

The minimal claim is therefore not that compositional constraints possess a uniquely privileged ontological status, but that their operational role depends on the descriptive level at which relational structure is organized and interpreted.

The framework therefore advances a structural and operational interpretation whose role depends on descriptive context rather than ontological priority.

5.7 Transition

Having developed a level-dependent interpretation of compositional constraints, we next examine how this framework relates to existing relational, informational, and geometric approaches in physics.

6 Compatibility with Existing Frameworks

The compositional framework developed in the preceding sections is intended to remain compatible with, rather than replace, established physical theories and relational approaches. Its purpose is to isolate a structural role that becomes relevant whenever relational descriptions are propagated, compared, or composed across multiple contexts.

In this section, we situate the framework relative to several existing relational, informational, and geometric approaches in physics.

6.1 Relational Quantum Mechanics

In relational quantum mechanics, physical properties are defined relative to interactions between systems rather than as absolute attributes [1, 5]. This perspective emphasizes the local formation of relational facts through interaction.

The present framework is compatible with this interpretation but addresses a distinct structural question: how relational information established within one interaction context may be admissibly propagated, compared, or composed across subsequent contexts involving additional systems.

In this sense:

- relational quantum mechanics provides a framework for relational fact formation;
- the present framework introduces compositional constraints governing admissible cross-context relational comparison.

The contribution developed here is therefore compositional rather than dynamical. It does not modify the formal structure of relational quantum mechanics or alter the local generation of relational facts. Instead, the framework introduces operational constraints regulating how relational information may participate in multi-context compositional processes.

6.2 Decoherence and Quantum Darwinism

Decoherence-based approaches explain how environmental interactions suppress interference and produce stable, effectively classical records [6, 8]. Extensions such as quantum Darwinism further emphasize the redundant encoding of information across environmental fragments [7].

These frameworks provide mechanisms for the stabilization and propagation of relational records. However, redundancy and environmental encoding alone do not by themselves specify a fully general compositional framework governing how relational information may be compared, translated, or propagated across arbitrary contexts.

Within the present framework:

- decoherence contributes to the stability conditions governing relational information;

- environmental encoding may realize specific instances of compositional propagation across contexts;
- and the present framework addresses the broader structural question of admissibility and cross-context composition.

Accordingly, decoherence and quantum Darwinism may be interpreted as providing physical realizations of particular compositional processes without exhausting the general role of admissibility and composition constraints within relational descriptions.

6.3 Gauge Theory and Transition Functions

Gauge theories provide a well-established example in which locally valid descriptions require additional structure to ensure global consistency [2]. Fields defined on overlapping regions are related through transition functions that maintain compatibility between local representations.

The present framework suggests a structural analogy:

- local relational descriptions may be compared schematically to local gauge representations;
- compositional maps between relational contexts play a role analogous to transition functions between overlapping patches.

The framework does not claim that relational fact spaces form gauge bundles or that interface maps are identical to gauge-theoretic transition functions. Rather, the analogy highlights a shared structural principle: local consistency alone does not guarantee globally admissible composition without additional compatibility constraints.

In this sense, the compositional constraints introduced here may be interpreted as an abstract analogue of transition structure governing admissible relational composition across contexts.

6.4 Quantum Information and Channels

In quantum information theory, transformations between subsystems are described using channels, instruments, and completely positive maps [10, 11]. These structures formalize how quantum states may be transmitted, transformed, filtered, or coarse-grained across interactions.

Within the present framework, compositional maps may in favorable cases be interpreted schematically as abstract representations of similar transformation processes:

- filtering corresponds to selective information propagation;
- coarse-graining corresponds to reduced effective descriptions;
- translation corresponds to basis, encoding, or representation changes.

These parallels suggest structural similarities between channel-based descriptions and the compositional framework developed here. The present work does not replace quantum information-theoretic constructions, but instead addresses the distinct question of how admissibility and composition constraints may regulate relational information across multiple contexts.

6.5 General Relativity and Causal Structure

In relativistic frameworks, spacetime geometry determines which systems may interact through causal structure [9]. This role corresponds closely to the accessibility relations introduced earlier in the present framework.

However, causal accessibility alone does not by itself determine how relational information established in one context is to be propagated, compared, or composed once communication between systems becomes possible. Geometry constrains whether interactions may occur, but does not fully specify the admissibility and compositional structure governing cross-context relational descriptions.

In this sense:

- spacetime geometry provides accessibility and causal-ordering constraints;
- the present framework addresses admissibility and compositional constraints acting on relational information across contexts.

These roles are complementary rather than competing. The framework developed here does not modify relativistic causal structure or spacetime dynamics, but instead isolates an additional structural question concerning how relational information may be consistently composed once causal accessibility is established.

6.6 Network and Distributed Systems

Related structural issues also arise in distributed systems and network theory [3]. In such systems, local records maintained by distinct nodes must be coordinated through synchronization rules, consensus protocols, or compatibility constraints.

These examples illustrate a general structural principle:

- local information alone does not guarantee globally consistent composition;
- additional rules governing communication, propagation, and reconciliation are often required.

This observation suggests that compositional consistency constraints are not unique to quantum or relativistic frameworks, but arise more broadly whenever relational information is distributed across multiple interacting contexts.

The present framework may therefore be interpreted as sharing structural similarities with distributed consistency mechanisms while applying these ideas to relational descriptions in physical systems.

6.7 Summary of Compatibility

Across the frameworks discussed above, a common structural pattern appears:

- local interactions generate relational information;
- accessibility or topology constrains which interactions may occur;
- additional compositional constraints become relevant when relational information is propagated or compared across multiple contexts.

This pattern suggests that the compositional framework developed here should not be interpreted as introducing a new physical ingredient or independent dynamical sector. Rather, it isolates a structural role that becomes relevant whenever relational descriptions must remain mutually admissible and compositionally consistent across distributed interaction contexts.

6.8 Transition

Having established compatibility with existing frameworks, we next examine representative classes of compositional constraints relevant to relational descriptions, including causality, consistency, stability, and information-theoretic limitations.

7 Minimal Physical Constraint Classes

The preceding sections introduced a compositional framework governing admissibility and relational composition across multiple contexts, and established its compatibility with several existing physical approaches. To connect this structural interpretation more directly to physical theory, we now identify representative classes of constraints that such compositional descriptions must satisfy.

These constraints are not proposed as a complete or unique specification. Rather, they represent broad categories of physical consistency conditions that any admissible compositional framework must satisfy in order to remain compatible with established physical principles.

7.1 Causality Constraints

A fundamental requirement on admissible relational descriptions is compatibility with causal structure. Relational configurations and the cross-context propagation of relational information must respect the ordering and accessibility relations permitted by the underlying physical framework.

In particular:

- relational information cannot be propagated between contexts lacking causal or interaction connectivity;
- compositional processes must respect temporal and causal ordering constraints;
- admissible compositional maps must not introduce acausal dependencies.

In relativistic settings, these conditions align naturally with the causal structure described by general relativity. More generally, they restrict admissible relational composition to interaction structures that remain physically realizable within the relevant accessibility constraints.

7.2 Consistency Constraints

Compositional constraints must ensure that relational descriptions remain internally consistent when propagated or compared across multiple contexts. The admissible combination of relational information must therefore avoid contradictions within the receiving relational framework.

Representative consistency constraints include:

- compatibility of relational descriptions across distinct contexts;
- preservation of internal consistency under admissible transformations;
- well-defined interpretation of composed relational information.

These conditions restrict admissible compositional maps to those that preserve compositionally consistent relational descriptions across extended interaction chains.

7.3 Stability Constraints

Not all admissible relational configurations contribute equally to persistent physical descriptions. For relational structures to remain compositionally relevant across extended interaction chains, they must satisfy appropriate stability conditions under interaction and propagation.

Representative stability constraints include:

- persistence of relational patterns across multiple interactions;
- stability under perturbations or environmental coupling;
- repeatability sufficient to support effective higher-level descriptions.

In physical systems, such stability conditions are often associated with decoherence, equilibration, or dynamical attractor behavior. Within the present framework, these considerations may be represented through admissibility constraints restricting relational configurations to those capable of remaining compositionally stable across the relevant interaction scales.

7.4 Information-Theoretic Constraints

Relational descriptions are subject to limitations associated with information transfer, encoding, storage, and transformation. Admissible compositional frameworks must therefore remain compatible with information-theoretic constraints governing how relational information may be propagated and represented across contexts.

Representative information-theoretic constraints include:

- limits on information propagation capacity;
- admissible forms of coarse-graining or compression;
- constraints on distinguishability or effective resolution between relational states.

Such limitations restrict how relational information may be transmitted, preserved, or transformed across extended interaction chains. Within the present framework, these constraints naturally give rise to filtering, coarse-graining, and finite-resolution behavior in admissible compositional maps.

7.5 Equivalence and Coarse-Graining Constraints

An important compositional role within the present framework is determining when distinct relational descriptions correspond to the same effective relational representation. This requires the introduction of equivalence relations together with admissible coarse-graining procedures.

These constraints specify:

- when two relational descriptions are treated as equivalent within a given context;
- how detailed relational information may be reduced to effective higher-level descriptions;
- how equivalence classes are preserved or modified under admissible compositional transformations.

Such constraints play an important role in constructing compositionally consistent multi-scale descriptions, in which detailed microscopic relational structure supports stable effective macroscopic descriptions.

7.6 Non-Uniqueness and Context Dependence

The constraint classes identified above do not uniquely determine a single universal compositional framework. Different physical regimes may exhibit different admissibility and compositional constraints depending on scale, interaction structure, and effective level of description.

Accordingly:

- the specific realization of compositional constraints may depend on physical context;
- multiple admissible constraint realizations may exist for the same relational system;
- the form of admissible compositional maps may vary across distinct physical domains.

The present framework therefore emphasizes the structural role and necessity of admissibility and compositional constraints rather than any claim of unique specification.

7.7 Minimal Claim

The purpose of this section is not to derive a unique compositional framework from first principles, but rather to identify representative physical consistency conditions that any admissible realization must satisfy.

We therefore adopt the following minimal claim:

Admissible compositional frameworks are constrained, at minimum, by causal accessibility, consistency of relational descriptions, stability of relational structures, and information-theoretic limitations.

This claim remains compatible with a wide range of underlying physical theories and leaves open the question of how such constraints arise or are realized within specific systems.

Taken together, these constraint classes illustrate a common structural role governing the conditions under which relational descriptions remain physically admissible and compositionally consistent across multiple contexts.

7.8 Transition

Having identified representative classes of physical consistency constraints, we now examine the limits of the present framework and clarify its intended scope and non-claims.

8 Limits and Non-Claims

The framework developed in this work is intentionally structural and interpretive. It introduces a level-dependent interpretation of admissibility and compositional constraints acting on relational descriptions across multiple contexts.

The purpose of this section is to clarify the intended scope of the framework and to distinguish its operational claims from stronger ontological, dynamical, or unification-based interpretations that are not established here.

8.1 Not a Replacement for Established Physical Theories

The present framework does not modify the predictive content of established physical theories such as general relativity or standard quantum mechanics. No changes are proposed to their mathematical formalisms, dynamical laws, or experimentally verified predictions.

Instead, the framework isolates an additional compositional and interpretive role associated with the admissibility and cross-context composition of relational descriptions. Its purpose is structural rather than dynamical: it does not replace or alter existing physical dynamics, but instead addresses how relational information may remain compositionally consistent across multiple contexts.

8.2 Not a New Microphysical Model

The present framework does not introduce new particles, forces, microscopic degrees of freedom, or hidden physical media. The compositional constraints discussed throughout this work are not proposed as independent dynamical entities or physical substances.

Instead, the framework is defined operationally through admissibility and compositional constraints acting on relational descriptions across multiple contexts.

Any attempt to identify specific microscopic realizations or underlying physical implementations of such constraints lies beyond the scope of the present work.

8.3 Not an Ontological Commitment

The present framework is intentionally ontology-neutral. The level-dependent interpretations developed in earlier sections are intended as operational and structural descriptions rather than claims about fundamental ontology.

In particular, the framework does not assert that:

- admissibility and compositional constraints are absolutely more fundamental than relational structure;
- physical reality is literally composed of interfaces or compositional maps;
- relational or compositional structure provides a final or complete description of nature.

The level-dependent interpretation developed here is intended to remain compatible with multiple ontological and interpretive frameworks rather than privileging a single foundational description.

8.4 Not a Resolution of Quantum Foundational Problems

The present framework does not resolve the quantum measurement problem, select a preferred interpretation of quantum mechanics, or eliminate the need for existing interpretational frameworks.

Instead, it introduces a structural distinction between:

- local relational fact formation;
- cross-context composition of relational descriptions.

The framework therefore addresses a compositional question that may arise within multiple interpretational settings without replacing or superseding them. At most, it may provide additional structural clarification concerning how relational information is propagated and compared across contexts.

8.5 No Uniqueness Claim for Compositional Constraints

The context dependence discussed in Section 7.6 should not be interpreted as implying a single canonical realization of admissibility and compositional constraints. The present framework identifies a class of structural consistency conditions rather than a unique implementation.

Different physical regimes may therefore realize such compositional constraints through distinct effective compositional maps, equivalence relations, coarse-graining procedures, or accessibility structures appropriate to the relevant physical context.

8.6 No Immediate Experimental Signature

The present framework is conceptual and structural in scope. In its present form, it does not introduce new experimental observables, measurable constants, or testable deviations from established physical theory.

Any potential empirical consequences would arise only after specifying explicit physical realizations of admissibility and compositional constraints within particular systems or dynamical settings.

8.7 Dependence on Idealized Modeling

The present framework employs abstract representations of systems, relational descriptions, and admissible compositional maps. These constructions function as idealized analytic tools rather than complete descriptions of physical systems.

Accordingly:

- the formalism does not attempt to capture the full complexity of experimental or dynamical systems;
- the definitions are intended to isolate structural and compositional features rather than provide exhaustive physical models;
- the conclusions developed here should be interpreted within the limits of the idealized modeling assumptions employed throughout the framework.

8.8 Scope of the Present Claim

Within the limits described above, the central claim of the present work may be stated as follows:

Admissibility and compositional constraints may admit different operational interpretations across levels of description, acting on already-established relational descriptions at one level while restricting the admissible organization of relational configurations at another.

This claim is structural rather than dynamical, interpretive rather than ontological, and general rather than tied to any single physical theory.

8.9 Transition

With the scope and limitations of the framework clarified, we conclude by summarizing the structural role of admissibility and compositional constraints within relational descriptions and outlining directions for future development.

9 Conclusion

This work has developed a level-dependent interpretation of admissibility and compositional constraints within relational physical frameworks. Building on prior results establishing the necessity of additional compositional structure for cross-context relational comparison, we have proposed that such constraints may be understood operationally as governing the admissibility and composition of relational descriptions across multiple contexts.

At the level of relational fact formation and comparison, these constraints act operationally on already-established relational information, regulating how relational descriptions may be translated, filtered, coarse-grained, or composed across interaction contexts. At a more abstract level, the same constraints may instead be interpreted as restricting the admissible organization of relational configurations themselves, determining which relations may be consistently realized and composed.

These complementary interpretations do not introduce circularity, but instead reflect a dependence on descriptive level. Within relational descriptions, admissibility and compositional constraints appear operationally emergent,

while at a more abstract level they may be interpreted as restricting the space of admissible relational organization. In this sense, the framework shifts emphasis away from questions of absolute ontological primacy and toward the structural conditions required for relational descriptions to remain compositionally consistent across extended interaction networks.

The framework is intentionally compatible with established physical approaches. It does not modify the formalism of quantum mechanics or general relativity, nor does it introduce new dynamical entities or microscopic degrees of freedom. Instead, it isolates a recurring structural role that appears across multiple relational and compositional settings, including relational quantum mechanics, decoherence-based descriptions, gauge-theoretic transition structure, and information-theoretic formulations. By distinguishing between relational fact formation, accessibility structure, and cross-context relational composition, the framework clarifies how local relational descriptions may remain compositionally consistent across distributed interaction contexts.

The identification of representative physical constraint classes—including causality, consistency, stability, and information-theoretic limitations—provides an initial step toward connecting abstract compositional constraints with physically admissible relational systems. However, the present work does not specify a unique realization of such constraints. Determining how admissibility and compositional conditions are instantiated within particular physical regimes remains an open problem.

Several directions for future work follow naturally. Admissibility and compositional constraints may be formalized more precisely using mathematical frameworks such as category-theoretic composition rules, network-based relational structures, or information-theoretic channel descriptions. In addition, physical systems involving horizons, boundary phenomena, decoherence environments, or strongly coupled interaction regimes may provide candidate realizations of such constraints. Exploring these systems may help clarify whether specific realizations possess identifiable phenomenological or experimentally accessible consequences.

The principal contribution of this work is therefore not the introduction of new physical entities, but the clarification of a structural role within relational descriptions. Once relational information is propagated or compared across multiple contexts, admissibility and compositional constraints become necessary components of compositionally consistent physical description. The present framework provides a language for identifying and organizing these

constraints while remaining compatible with multiple underlying physical and interpretive frameworks.

In this sense, the central conclusion may be stated simply:

Relational structure alone does not determine how relational information may be consistently propagated, compared, or composed across multiple contexts. Admissibility and compositional constraints specify the conditions under which relational descriptions remain physically meaningful and compositionally consistent.

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